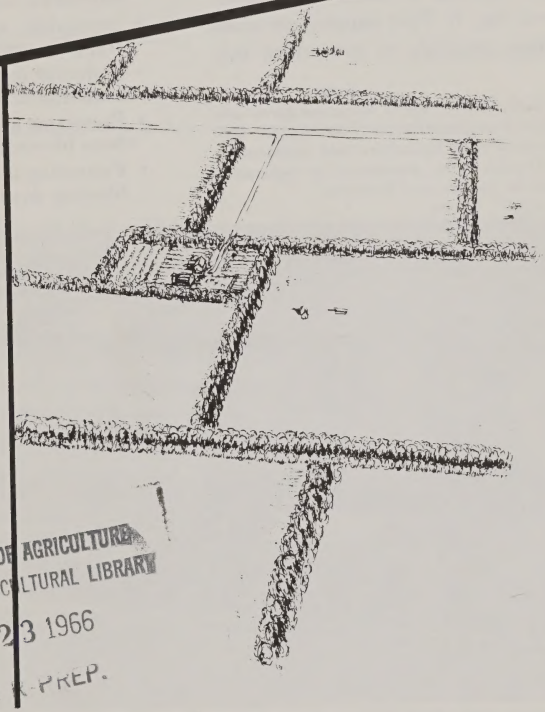
Windbreaks
for the Central Great Plains

1 How to use trees to protect land and crops



Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

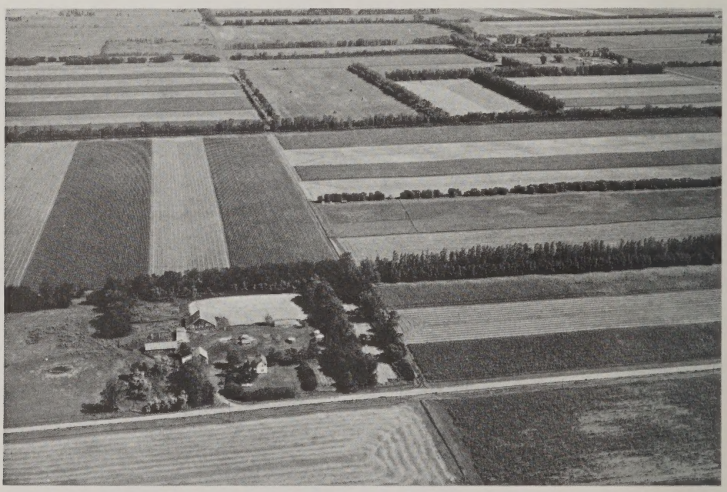
How to Use Trees to Protect Land and Crops

by RALPH A. READ[1]

Field windbreaks, often called shelterbelts, are long, narrow strips of trees and shrubs, planted in various patterns to check wind movement (fig. 1). They supplement usual tillage methods in conserving soil, plant, and water resources and provide protection by—

- Reducing soil blowing on clean cultivated fields.
- Improving soil moisture by trapping snow.
- Reducing moisture losses from evaporation.
- Protecting newly seeded crops from blowing out.
- Protecting mature crops from blowing down.

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*



SCS-SD-600

Figure 1.—Patterns of shelterbelts on cultivated fields protect soils from wind erosion and provide a more favorable microclimate for the growth of crops.

A pattern of shelterbelts will modify the local climate of fields (fig. 2). In the area protected by the shelterbelt, the windspeed and rate of evaporation are greatly reduced. The air humidity is higher. Changes in air temperature are moderated, as is true of surface soil temperatures. The catch of snowfall and soil moisture is increased.

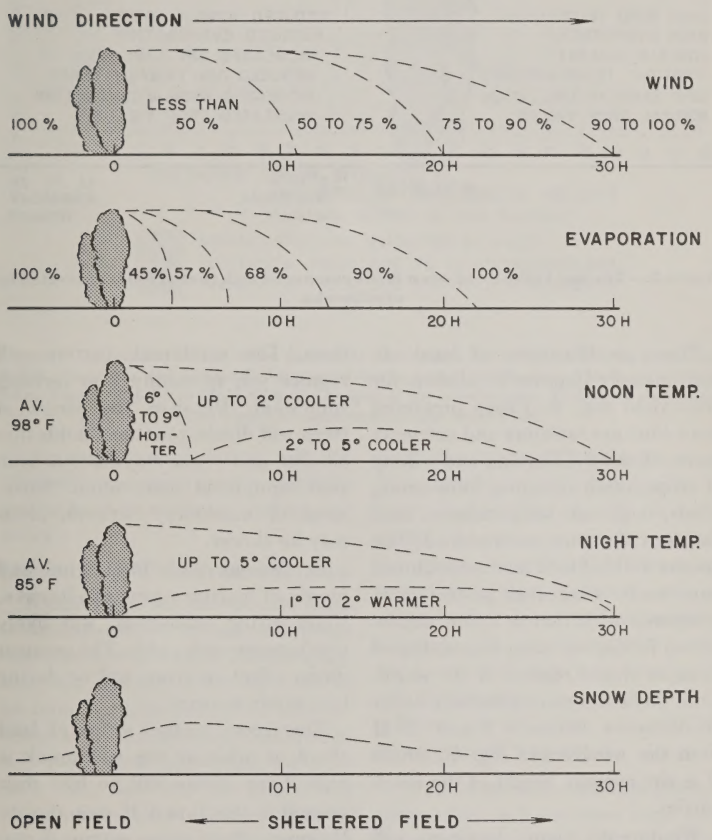


Figure 2.—Windbreaks modify environmental conditions of fields they protect. Reducing wind velocity brings about changes in evaporation, humidity, temperature, and snow accumulation. (H=average windbreak height.)

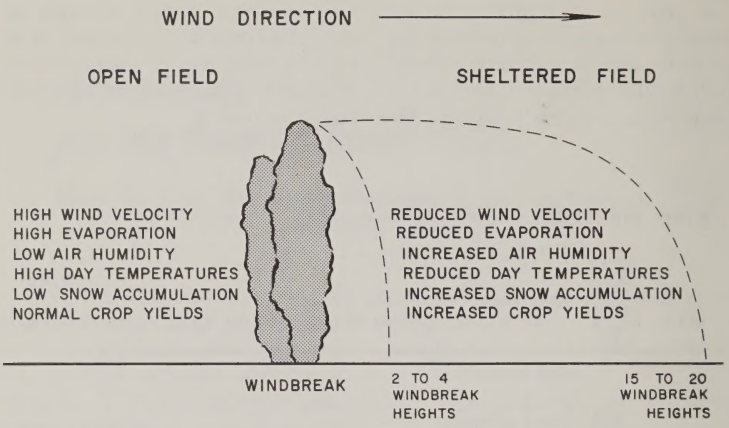


Figure 3.—The local climate of open fields compared with that of fields protected by windbreaks.

These modifications of local climate usually improve conditions for crop yield (fig. 3). Crops protected from wind use moisture and nutrients more efficiently. Burning and wilting of crops, often resulting from strong winds, high air temperatures, and deficient moisture, are reduced. The greater yield of field and horticultural crops under windbreak protection as compared with that in open, unprotected fields, has been demonstrated in many windy regions of the world. Crop yield increases generally occur at distances between 2 and 15 H from the windbreaks (fig. 4), where H is the average height of the windbarrier.

Windbreaks alone, however, will not provide the complete soil protection needed against extremely strong winds; they must be combined with other soil management practices. The windbreak pattern will require you to modify your farming somewhat. Because the strips of trees will divide your open fields into smaller units, you may have to turn your equipment more often. Movement of machinery between fields may be slower.

In seasons with little wind and plenty of moisture your windbreaks, while giving protection, will likely not increase crop yields. The greatest direct effect on crops will be during hot, windy seasons.

Tree roots occupy strips of land about as wide as the windbreak is high. Crop yields will be less than normal in this 0 to 1 H strip (fig. 4). However, these strips occupy 5 percent or less of the land influenced by field windbreaks—a very small area compared to the larger area on which real benefits are obtained. In

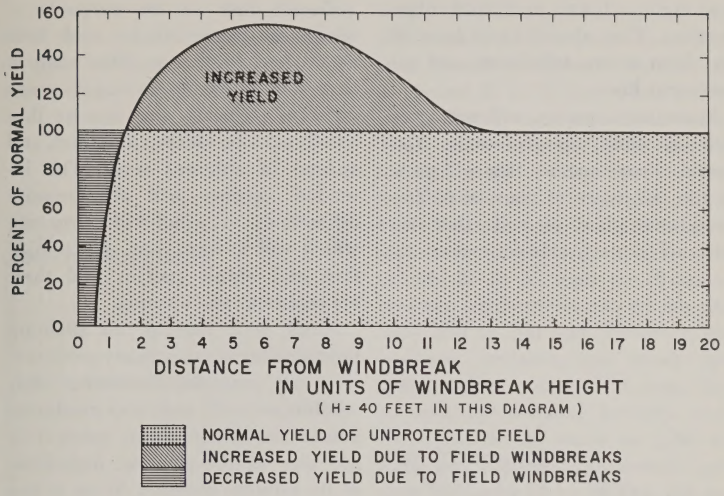


Figure 4.—Because of the more favorable conditions for crop growth on protected fields, the yields are generally increased in the zone of influence. This zone extends from 1 or 2 H to 12 to 20 H (H is the height of the windbreak). Yields are decreased in the narrow zone nearest the shelterbelt.

most cases these strips can be planted to perennial grasses or alfalfa and utilized as roadways and turning areas.

How to Plan Windbreak Patterns

Windbreaks are permanent, long-term investments in soil and water conservation, and only careful planning can prevent costly mistakes in location, species selection, tree arrangement, and spacing. Shelterbelts will give some protection early in their life, but will not reach full effectiveness until maturity in 20 to 30 years. If properly maintained and protected, they will remain useful in most situations for another 30 years.

The planning and establishment of windbreak systems should be a part of your overall farm planning. The locations and distribution of your shelterbelts depend on soils, kinds of crops, topography, prevailing winds, location of buildings, terraces, waterways, pastures, and on other land uses or public facilities. Locating the windbreak tree strips on a map will help you do a better job of planning your protection in relation to all other conservation practices and land uses.

Field windbreaks should be planted where they will interfere least with other land uses or public facilities. For example, to minimize problems of snow and soil drifting and blind intersections, they should not be planted less than 300 feet from high-

way rights-of-way and road intersections. They should be at least 50 feet from power, telephone, and gas easement lines.

Some tree species will not grow well on some types of soils. You should choose species that will grow on the soil types of your land. You should not plant on soils that are extremely unfavorable for trees.

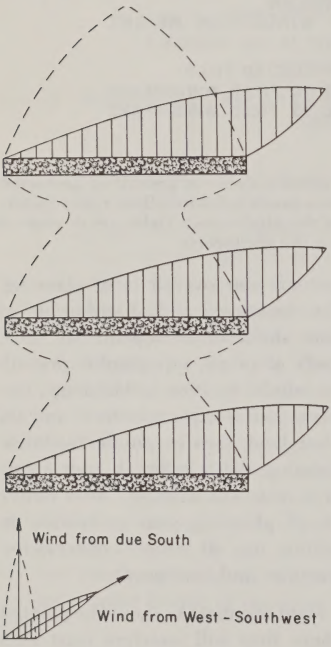


Figure 5.—A series of parallel windbreaks gives adequate protection only when the wind is perpendicular to the barriers. Protected area decreases as wind direction shifts.

Decide first on the purposes of windbreak protection for each field or unit of land use. This step is essential in the beginning because different purposes may require that windbreaks be located, oriented, and spaced in different ways. The intended purpose will also require differences in windbreak structure which will govern your selection of tree and shrub species and their arrangement and spacing.

Limit your reasons for planting field windbreaks to primary purposes, if at all possible. Remember that wildlife, esthetic, and other incidental values are nearly always present in any type of tree planting, regardless of its primary purpose. Some of the primary purposes in establishing field windbreak patterns are:

- To reduce soil erosion and wind damage to crops.
- To protect growing crops from extremely hot, drying winds throughout the growing season.
- To provide better retention and distribution of snow on fields.
- To reduce evaporation and improve distribution of sprinkler irrigation water.

How to Orient and Space Windbreaks

A series of parallel windbreaks oriented at right angles to prevailing winds will provide fair protection (fig. 5). However, a pattern of windbreaks

in which fields are closed on all sides is the only pattern that will furnish complete protection when winds shift direction (fig. 6).

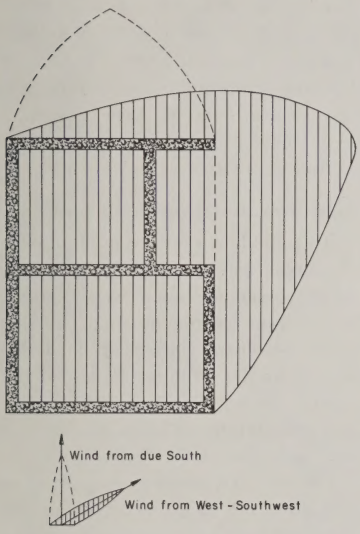


Figure 6.—A closed pattern of windbreaks gives maximum protection at all times, regardless of shifting wind direction.

The distance between parallel windbreaks on level fields should not exceed 20 times the average height that your tallest trees can attain in 20 years. A closer interval of 10 to 15 times the maximum height will increase the protection. On sloping land the strips should follow the field contours or terraces, and be spaced at 10 to 15 H intervals.

Since trees do not grow as tall on upland sites as on the wetter lowlands, the actual 20 H distance between shelterbelts on uplands will be less than on lowlands. The mature height of Siberian elms, ponderosa pines, and Austrian pines on upland soils in central Nebraska and Kansas is around 45 to 50 feet. Elms attain this in 20 years and pines in 40 years. Thus, the maximum 20 H interval for shelterbelts on these soils is 900 to 1,000 feet. In the western plains of Nebraska and Kansas where mature tree height on upland soils is only 25 to 35 feet, the distance between shelterbelts should not exceed 500 to 700 feet. However, on lowlands, terraces, and sandy uplands with a water table near the surface, the distance between tree strips can be as much as 1,200 to 1,500 feet because cottonwoods and elms will grow 70 to 80 feet tall on these sites.

If more complete field protection is desired during the first 10 years after planting, before your tall trees have reached their maximum heights, plant single rows of fast-growing broadleaf species halfway between your main windbreaks. Then remove them when the main shelterbelts reach maximum height and effectiveness.

Windbreaks Should Have Continuity

A gap in a shelterbelt will admit and accelerate the wind. Besides increasing the likelihood of soil erosion, the increased windspeed through the gap will harm the trees growing nearby.

The likelihood of gaps or weak spots in a windbreak can be lessened in several ways. Tree strips should be located to avoid spots of unfavorable soil where trees may die early

or become stunted in height. Early failures should be replanted within the first 2 years after the initial planting.

Gaps that are necessary for access roads or lanes to the fields should angle or curve, rather than go straight through the windbreaks. Corners of windbreak patterns should be rounded and reinforced with extra shrubs and conifers. The ends of tree strips should be planted with extra shrubs and conifers to provide dense lower foliage.

Windbreaks Should Have Foliage Density

To function properly, windbreaks should be moderately dense. Needed density is achieved in two ways—

- By using tree and shrub species that have fairly dense foliage and compact crown form.
- By using more tree and shrub rows.

Although windbreaks must be narrow so as to occupy a minimum of cropland space, they must have enough tree rows in the proper arrangement to provide enough density for checking wind movement. If moderately dense foliage is required only at middle and upper heights, barriers need be only two or three rows wide. More rows are usually needed if density is required at all heights. We do not recommend single row shelterbelts because loss of a few trees will result in gaps that reduce protective value.

Windbreaks Should Be Tall

To provide a sheltering effect over the largest possible acreage with minimum space occupied by the trees, windbreaks should be tall. The distance between windbreaks is determined by the effective height of the mature trees. Therefore, if your soils will grow tall trees, fewer windbreaks will be required.

Choose fast-growing species that will grow tall in 20 to 30 years, and that will live long enough to remain effective for 30 to 50 years. Information on heights attained by various tree species at maturity on various soils is given in leaflet 2.

The information in this leaflet can help you in initial planning for use of windbreaks, or shelterbelts, on your lands. The details of tree species selection, arrangement, and spacing for individual windbreaks are given in leaflets 2 and 3. Windbreaks are discussed in detail in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. Your local Soil Conservation Service technician, county agent, or State forester will be glad to discuss windbreaks with you. He will help you in planning a windbreak system especially suited to your own land conditions.

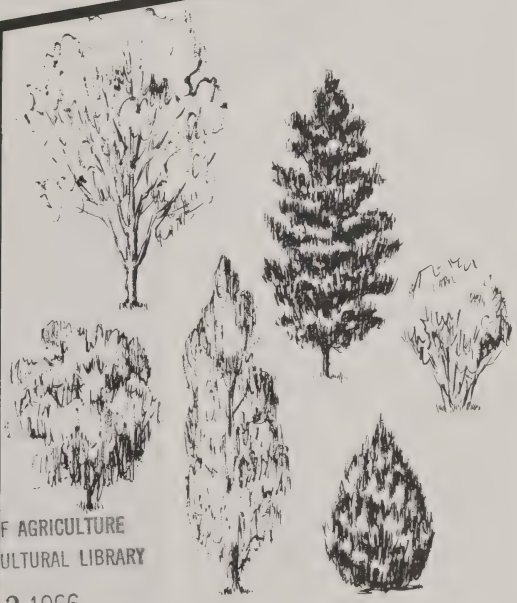
Issued September 1965

GPO 851 - 213 - 7

Windbreaks for the Central Great Plains

2

How to select tree and shrub species



Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Select Tree and Shrub Species

by RALPH A. READ[1]

Windbreaks (or shelterbelts) are strips or belts of trees and shrubs planted in patterns to check wind movement. In the Central Great Plains shelterbelts are especially important for conserving soil, plant, and water resources; protecting and improving crops; protecting farmsteads and animals from extremes of weather; and keeping road systems passable during winter. Establishment of effective and permanent shelterbelt systems in the Plains depends largely on the choice of tree and shrub species.

To be successful in windbreaks, trees and shrubs must meet two major requirements. First and most important, they must be adapted to the climate and soil. In general, this means they can be established and will grow well for at least 30 years before deteriorating. Second, they must be able to grow in close association with other tree species and have growth characteristics, foliage, and crown form that will produce the desired density and type of shelterbelt structure.

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Neb., maintained in cooperation with the University of Nebraska.*

Select Species Adapted to the Environment

When you choose the shrubs and trees for your windbreak, select species best suited to the Plains climate and soil. Those poorly suited will lack vigor and may die young. Well-adapted species should grow and thrive for many years. Whereas some species have a built-in adaptation to the wide range of climate and soils of the Plains, others are suited to a very narrow range of conditions. The following conditions should be borne in mind when making your choice of species for windbreaks.

Trees and shrubs in the Plains must be able to withstand strong winds and extreme dryness. They must be able to survive extremes of air temperature ranging from 30° below zero to over 115° F. Rapid changes in air temperature and humidity must be endured.

Trees and shrubs in the Plains must also be able to grow on a wide variety of soils. Whereas most will grow well on deep, moist, fertile soils, relatively few species can tolerate very alkaline, very acid, very shallow, or very stiff, impermeable soils.

Disease and insect pests must be tolerated and overcome by the trees and shrubs in the Plains. Those plants weakened by drought and mechanical damage are more susceptible to attack by insects and diseases; therefore, special resistance to some of the major insect and disease pests is needed. However, susceptiblility to minor pests need not limit your choice of species, especially if the trees have other desirable characteristics.

Select Species that Have Desirable Windbreak Characteristics

The ability of a windbreak to furnish protection depends largely on the characteristics of the individual shrubs and trees that constitute the shelterbelt (fig. 1). These trees and shrubs must have ability to grow in rather close association with each other; they should have compact crowns and dense foliage; strong stems and branches to withstand the wind; a deep, well-distributed root system; capability of retaining lower branches and foliage as the tree grows in height; and a fairly uniform rate of height growth.

F-503714

Figure 1.—Siouxland selection of common cottonwood is not only resistant to leaf rust disease, but also grows as much as 40 feet tall in 6 years, making it a good choice for early effective height.

Height—The maximum height that windbreak trees can attain will determine the distance between your windbarriers and consequently the size of the area protected. The taller the windbreak, the greater the area protected with a minimum of land occupied by trees (fig. 2). Therefore, choose tree species that will grow tallest on your particular soil types.

For tall windbreaks in the shortest time, choose cottonwood, willow, sycamore, or Siberian elm. Choose conifers, such as ponderosa pine, Austrian pine, or shortleaf pine, for tall trees of slower growth, but of longer life.

Density (foliage characteristics).—Most conifers suited for use in Plains shelterbelts have fairly dense, compact crowns that retain foliage throughout the year. In contrast, the broadleaf trees and shrubs lose foliage in the fall and cause shelterbelts to have different densities in summer and winter.

Density of the upper level of a shelterbelt depends on the crowns of the tallest trees. Fast-growing Siberian elms and cottonwoods provide this for 25 to 30 years, but for long-lived upper-level foliage density you should use ponderosa, Austrian, or shortleaf pine.

F-503713, 503721

Figure 2.—Ponderosa pines with a tall, compact crown form make better windbreak trees than those with short, wider crowns.

Foliage density at the middle level of shelterbelts will be provided by the fast-growing broadleaf trees for the first 15 years. After that, the pines and red cedars will provide it.

Lower level density is, of course, provided by all rows of trees when they are young. But after 20 to 30 years most conifers and broadleaf trees will lose their lower foliage. Thickly growing shrubbery species must then be relied on to provide foliage density near the ground.

Recommended Species

Field testing and examination of plantations throughout the Plains region have given us reliable information about the best trees and shrubs for windbreaks. Over the past 50 years the older plantations have experienced severe drought as well as more favorable conditions. Many species and varieties not mentioned in this leaflet have been tried and tested. Although some of them may be useful under certain conditions, they are not generally recommended.

Trees and shrubs suitable for windbreaks in the Central Plains (fig. 3) are listed in the following tables. To select the trees most suitable for your needs, first locate the table which most nearly describes your planting site as to soil and topography. Then from the species listed, select tall trees, medium trees, short trees, and shrubs as needed. The maximum heights, rates of growth, and longevity are for average situations in central Nebraska and Kansas. Ex-

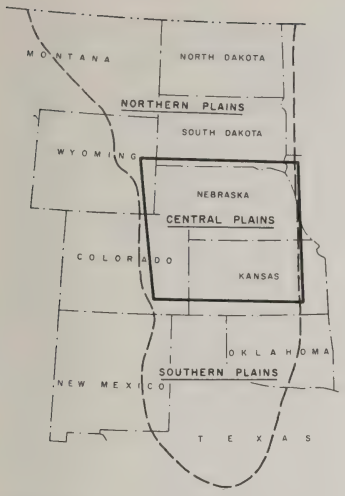


Figure 3.—Central area of the Great Plains to which species recommendations apply.

pected growth would be 10 to 20 percent more in the moister eastern areas; and 10 to 20 percent less in the western areas.

The kinds of trees selected should be held to the minimum needed for the density of barrier you want. You may, for example, not wish to use a short tree if you have selected a shrub and medium tree that will give adequate density near the ground. Needing only one tall, fast-growing tree, you would choose either Siberian elm or cottonwood, not both. In selecting species, you should also consult the table giving characteristics of crown density, rooting habit, and drought resistance.

Recommended tree and shrub species for MEDIUM TO DEEP UPLAND SOILS of sandy loams and loamy sands

Mature size	Common name	Maximum height feet	Height growth	Useful life
TALL TREES	Cottonwood	60	Fast	Short
	Siberian elm	50	Fast	Medium
	Shortleaf pine (So. Kans. only)	50	Medium	Medium
	Ponderosa pine	60	Slow	Long
	Austrian pine	50	Slow	Long
MEDIUM TREES	Green ash	30	Medium	Medium
	Bur oak	35	Slow	Long
	Eastern red cedar	35	Slow	Long
SHORT-TREES	Boxelder	20	Fast	Short
	Russian-olive	20	Fast	Short
	Russian-mulberry	15	Medium	Short
	Osage-orange	20	Medium	Long
	Rocky Mtn. juniper	25	Slow	Long
SHRUBS	American plum	8	Fast	Medium
	Chokecherry	8	Fast	Medium
	Common lilac	8	Medium	Medium
	Skunkbush sumac	5	Slow	Medium

Recommended tree and shrub species for DEEP, MOIST, PERMEABLE SOILS of river and creek lowlands

Mature size	Common name	Maximum height feet	Height growth	Useful life
TALL TREES	Cottonwood	80	Fast	Medium
	White willow	50	Fast	Medium
	Siberian elm	60	Fast	Medium
	Sycamore	60	Medium	Medium
	Shortleaf pine (So. Kans. only)	60	Medium	Medium
	Ponderosa pine	60	Slow	Long
	Austrian pine	60	Slow	Long
MEDIUM TREES	Northern catalpa	40	Fast	Medium
	Black willow	40	Fast	Short
	Golden willow	30	Fast	Short
	Green ash	45	Medium	Medium
	Hackberry	45	Medium	Medium
	Bur oak	45	Slow	Long
	Scots pine	45	Medium	Medium
	Jack pine	45	Medium	Medium
	Eastern red cedar	45	Slow	Long
SHORT TREES	Boxelder	25	Fast	Short
	Russian-olive	25	Fast	Medium
	Diamond willow	15	Medium	Short
	Russian mulberry	20	Medium	Medium
	Osage-orange	25	Medium	Long
	Rocky Mtn. juniper	25	Slow	Long
SHRUBS	American plum	10	Fast	Medium
	Chokecherry	10	Fast	Medium
	Tamarisk (Kans. only)	10	Fast	Short
	Purple willow	6	Fast	Short
	Common lilac	8	Medium	Medium
	Honeysuckle (Nebr. only)	8	Medium	Short
	Caragana (Nebr. only)	10	Medium	Medium

Recommended tree and shrub species for MEDIUM TO SHALLOW UPLAND SOILS underlain by coarse sand, gravel, impermeable claypan, or bedrock

TALL TREES	Siberian elm	25	Medium	Short
	Ponderosa pine	35	Slow	Medium
MEDIUM TREES	Bur oak	30	Slow	Medium
	Eastern red cedar	25	Slow	Long
SHORT TREES	Osage-orange	20	Medium	Medium
	Rocky Mtn. juniper	15	Slow	Long
SHRUBS	American plum	5	Medium	Short
	Tamarisk (Kans. only)	5	Medium	Short
	Common lilac	5	Slow	Short
	Skunkbush sumac	5	Slow	Medium

Recommended tree and shrub species for MEDIUM TO DEEP UPLAND SOILS of silty or clayey loams.

Mature size	Common name	Maximum height feet	Height growth	Useful life
TALL TREES	Siberian elm	45	Fast	Medium
	Shortleaf pine (So. Kans. only)	45	Slow	Medium
	Ponderosa pine	50	Slow	Long
	Austrian pine	45	Slow	Medium
MEDIUM TREES	Green ash	35	Medium	Medium
	Hackberry	35	Medium	Medium
	Bur oak	35	Slow	Long
	Eastern red cedar	35	Slow	Long
SHORT TREES	Boxelder	25	Fast	Short
	Russian-olive	25	Fast	Short
	Russian-mulberry	20	Medium	Short
	Osage-orange	25	Medium	Long
	Rocky Mtn. juniper	25	Slow	Long
SHRUBS	American plum	10	Fast	Medium
	Chokecherry	10	Fast	Medium
	Tamarisk (Kans. only)	10	Fast	Short
	Common lilac	8	Medium	Medium
	Caragana	8	Medium	Medium
	Skunkbush sumac	6	Slow	Medium

Recommended tree and shrub species for SANDHILL UPLANDS

TALL TREES	Ponderosa pine	50	Slow	Long
	Austrian pine	40	Slow	Medium
MEDIUM TREES	Scots pine	40	Medium	Medium
	Jack pine	40	Medium	Medium
	Eastern red cedar	30	Slow	Long
SHORT TREES	Rocky Mtn. juniper	20	Slow	Long
SHRUBS	Chokecherry	6	Medium	Medium

Recommended tree and shrub species for VERY WET, POORLY DRAINED SOILS of saline or alkaline uplands and lowlands

TALL TREES	Cottonwood	45	Medium	Short
	White willow	30	Medium	Short
	Siberian elm	25	Medium	Short
MEDIUM TREES	Golden willow	20	Medium	Short
	Green ash	20	Slow	Short
SHORT TREES	Russian-olive	15	Medium	Short
	Diamond willow	5	Medium	Short
SHRUBS	Purple willow	5	Medium	Short

Crown, root, and drought characteristics of recommended species

Mature size	Common name	Crown density	Root habit	Drought resistance
TALL TREES	Cottonwood	Medium	Shallow	Low
	White willow	Medium	Shallow	Low
	Siberian elm	Dense	Medium	Medium
	Sycamore	Dense	Medium	Low
	Shortleaf pine	Medium	Medium	High
	Ponderosa pine	Dense	Deep	High
	Austrian pine	Dense	Deep	Medium
MEDIUM TREES	Northern catalpa	Medium	Shallow	Low
	Black willow	Medium	Shallow	Low
	Golden willow	Dense	Shallow	Low
	Green ash	Medium	Medium	Medium
	Hackberry	Medium	Deep	High
	Bur oak	Dense	Deep	High
	Scots pine	Medium	Deep	Medium
	Jack pine	Medium	Medium	Medium
	Eastern red cedar	Dense	Deep	High
SHORT TREES	Boxelder	Dense	Medium	Medium
	Russian-olive	Medium	Medium	Medium
	Diamond willow	Medium	Shallow	Low
	Russian mulberry	Dense	Deep	Medium
	Osage-orange	Dense	Deep	High
	Rocky Mtn. juniper	Dense	Medium	High
SHRUBS	American plum	Dense	Shallow	Medium
	Chokecherry	Dense	Shallow	High
	Tamarisk	Medium	Shallow	Medium
	Purple willow	Medium	Shallow	Low
	Common lilac	Dense	Shallow	High
	Honeysuckle	Dense	Shallow	Medium
	Caragana	Medium	Shallow	High
	Skunkbush sumac	Dense	Medium	High

The information in this leaflet can help you decide which trees to use in the Central Plains. For recommended tree and shrub species for the Northern and Southern Great Plains, see publications of the U.S. Department of Agriculture and State experiment stations. Windbreaks are discussed in detail in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. For local help in selecting species and establishing your shelterbelt, or windbreak, consult your local Soil Conservation Service technician, county agent, or State forester.

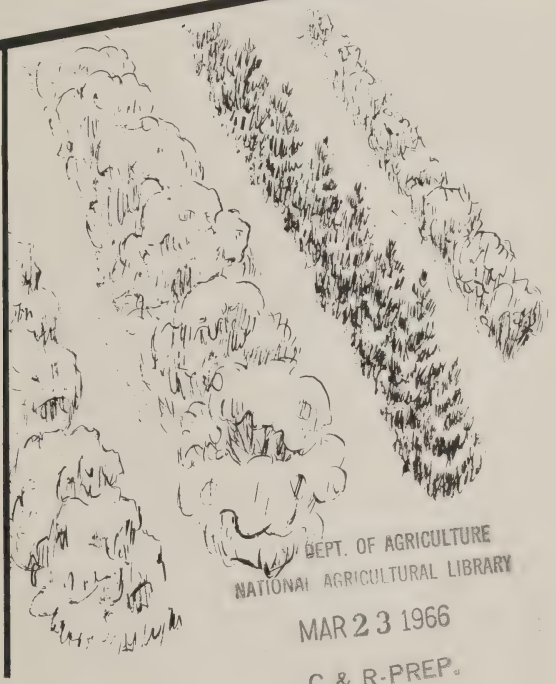
Issued September 1965

GPO 851-213-2

Windbreaks for the Central Great Plains

3

How to arrange and space trees and shrubs



Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Arrange and Space Trees and Shrubs in Field Windbreaks

by RALPH A. READ[1]

Since windbreaks (often called shelterbelts) are planted to reduce the force of wind, the total effect of all trees composing the barrier is more important than the effect of any individual tree. However, the individual trees must have space enough to grow well, in order to contribute their share to the wind-reduction effect.

The spacing and arrangement of trees must often be a compromise between: (1) The space required for maximum growth of the individual tree, and (2) the crowding required to get sufficient density to make an effective windbarrier.

Trees require large amounts of moisture to grow satisfactorily. Normally where moisture is scant, more space will be needed by each tree. Fortunately, however, once tree stands are established, their very presence tends to increase the moisture available by trapping snow and reducing evaporation. Tree roots grow deeply and therefore have access to soil moisture not available to most crop plants.

An additional consideration in spacing trees in windbreaks is the type of cultivation equipment available on the farm. Tractor cultivation with wide implements requires that tree rows be spaced farther apart than normally recommended for tree plantations.

Growth and Development of Windbreaks

How windbreaks grow affects their management throughout their lifetime and the initial spacing of the trees. Height, density, cross section, and profile will change as the tree crowns merge, then as the trees gradually decline in vigor, and as tree reproduction develops. Such changes naturally affect the structure and wind resistance of shelterbelts.

During the first 20 years your shelterbelts will develop rapidly in height and density. Spacing of trees and shrubs should be moderately close at the beginning, so that barriers become effective as early as possible and cultivation can be stopped. The tree crowns will close together, form-

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*

ing a continuous barrier. Thereafter, the growth and development will depend largely on the kinds of trees in your shelterbelts, their ability to sustain growth, and the way you manage the stand. Series leaflet 7 and Agriculture Handbook 250 tell how to manage windbreaks during 10 to 20 years after planting.

In shelterbelts composed entirely of broadleaf trees, you can expect a gradual decline and loss of effectiveness after 30 to 40 years (fig. 1). Shelterbelts containing conifers, however, will remain effective for 40 to 50 years or more (fig. 2). At about 30 years of age the pines will begin to function as the tall component of your shelterbelt, taking the place of the fast-growing broadleaf trees. At this time the tall broadleaf trees should be removed.

Arrangement of Species

Arrangement and spacing of the different tree and shrub species in a windbreak will determine the cross section form. Windbreaks with an abrupt or nearly vertical cross section are more effective than those with

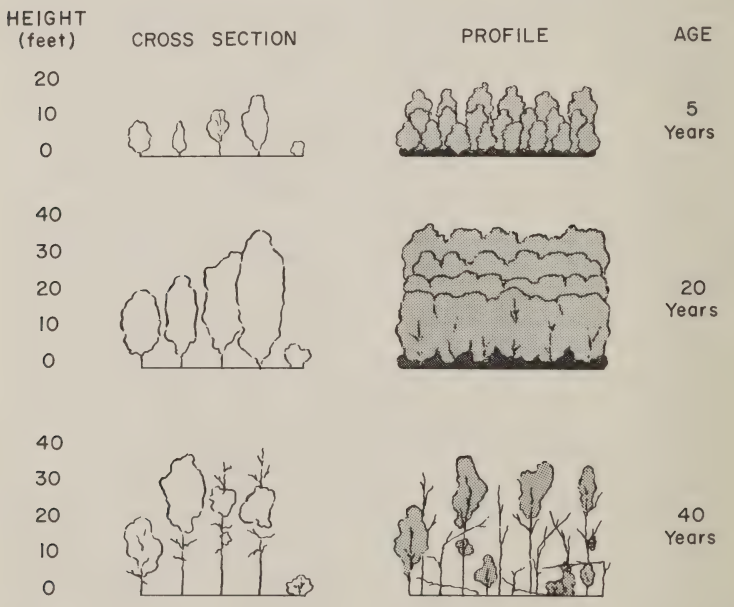


Figure 1.—Compared with shelterbelts containing conifers, those composed only of broadleaf species will produce an effective barrier early in life, but will begin to deteriorate after 30 to 40 years.

an inclined cross section. The trees should therefore be arranged to form barriers with vertical sides toward the wind. This can be arranged by planting the tall, fast-growing species, such as Siberian elm or cottonwood, in the outside rows of the shelterbelt. The outside-row location of these short-lived species will favor their easy removal after 30 years or so. After these tall broadleaf species are removed, the tall, slower growing conifers will provide a nearly vertical barrier.

The conifers—pines and red cedars—should form the backbone of your windbreaks. The pines will be the tallest trees after 40 years, so place them in the center position. Flank the pines with red cedars, shrubs, or both.

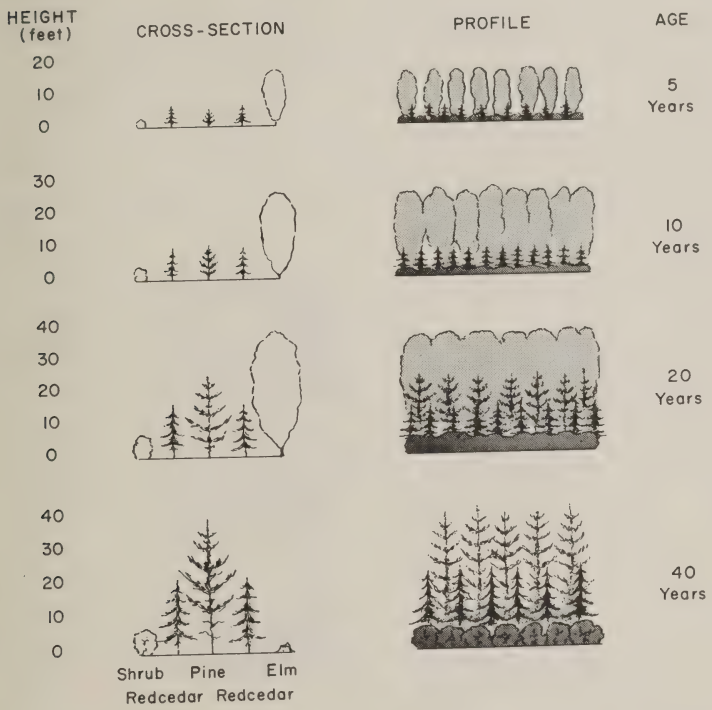


Figure 2.—As the trees in a windbreak grow, the structure of the windbreak develops. The density of the profile (the wind-slowing aspect of the barrier) changes. Long-lived conifers, although slow in producing an effective barrier, will remain effective for 40 years or more.

Fast-growing broadleaf trees such as Siberian elm, cottonwood, Russian-olive, and boxelder should be planted no closer than 20 feet to conifer rows. This is necessary to prevent the crowding and overtopping of conifers by the fast growers. Conifers, especially the pines, lose foliage on lower branches and lose height growth when crowded and shaded.

Two or more species of different growth rates should not be mixed or alternated within the same row. Keep each species of tree or shrub in its own row, except where a change in soil condition requires an entirely different set of species.

Spacing Between Tree Rows

Distance between tree rows can be varied considerably without appreciably affecting the density, height, and continuity of shelterbelts (fig. 3). The profile of a shelterbelt, which with density determines its effectiveness in slowing wind, is approximately the same whether the tree rows are 10 feet or 20 feet apart. Other advantages and disadvantages of close or wide spacing are important, however, and should be considered.

Widely spaced rows will allow more space per tree for root development and moisture use; this is important in the western Plains where soil moisture is likely to be limited. Widely spaced rows will also allow more space for cultivation with large equipment. On the other hand, widely spaced rows will take more land out

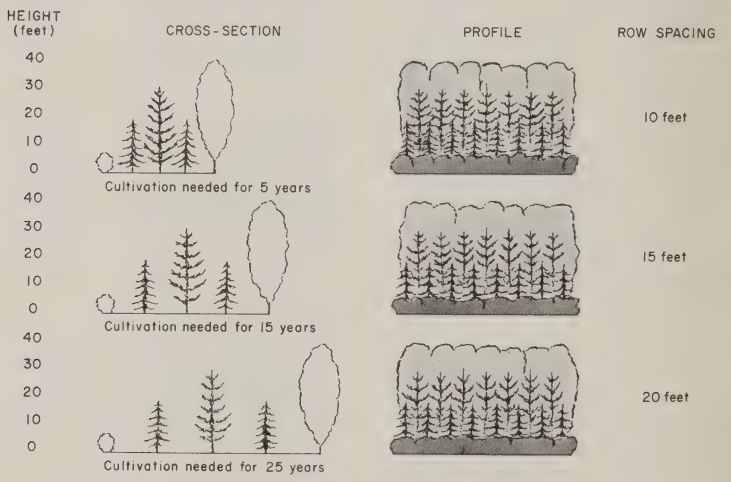


Figure 3.—The distance between rows of trees in a shelterbelt does not appreciably affect the profile and density. The wind-slowing ability is about the same, whether tree rows are 10 or 20 feet apart.

of crop production and will need to be cultivated many more years.

Closely spaced rows will grow together early and thereby reduce the number of years of cultivation. Closely spaced rows will produce the densest, most compact barrier occupying a minimum of land area. With the closer rows, however, you will have to do some thinning and other cultural work as the trees grow older.

Spacing between tree rows should be no less than 10 feet and no more than 20 feet. Use the wide spacing only where necessary to accommodate large cultivation equipment and to separate a row of conifers from a row of fast-growing broadleafs.

Spacing Between Trees in the Row

The distance between the trees in the row will directly affect the density of windbreaks (fig. 4). If trees and shrubs are spaced too far apart in the row, the time required for the shelterbelts to attain effective density will be needlessly prolonged. On the other hand, if trees are spaced too closely there will be danger of early crowding and loss of growth and vigor. Trees and shrubs should be spaced so their crowns will close together and form a continuous barrier by the time they are 10 years old.

Because the various kinds of trees and shrubs used in windbreaks grow at different rates in height and crown spread, the spacing between them in the row will depend upon the species.

Tall, fast-growing trees like cottonwood and Siberian elm should be spaced 8 to 12 feet apart. The closer spacing will form an effective barrier sooner. If you use the closer spacing, you should thin the windbreak within 5 to 10 years.

Slower growing conifers, like the pines and junipers, should be spaced 6 to 8 feet apart in the row. After 10 to 15 years you should thin these rows to prevent crowding and loss of lower limbs. Position of trees in adjacent rows should be staggered or alternated to give a more uniform foliage density.

Most shrubs should be planted 3 to 5 feet apart. The closer spacing will provide a dense lower level within a few years, which will prevent wind and snow blowing through beneath the trees.

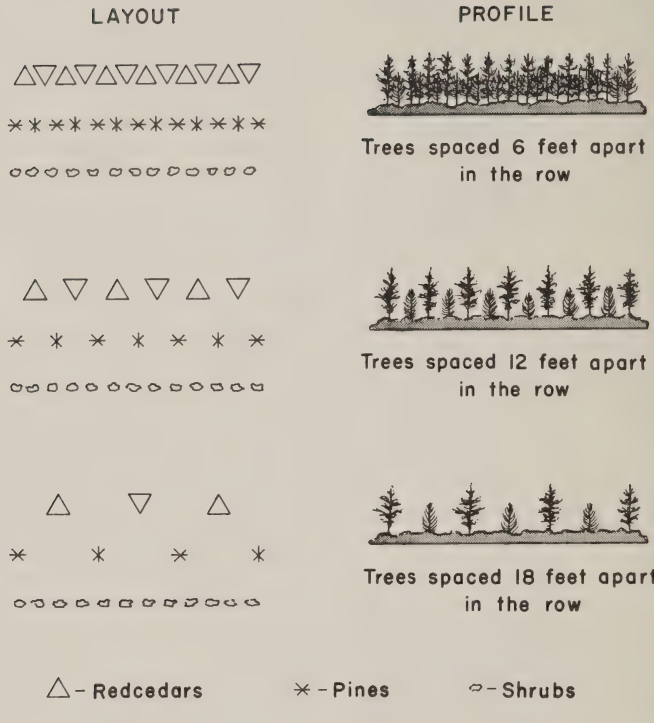


Figure 4.—The spacing between the trees or shrubs within a row affects the density and profile of a windbreak. Spacing from 6 to 8 feet apart in the row makes an effective profile. When trees are too far apart, the profile is too open to slow the wind.

More information on arrangement and spacing of trees in windbreaks or shelterbelts can be found in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. Your local Soil Conservation Service technician, county agent, or State forester will be glad to discuss tree spacing and arrangement problems with you. He will assist you in designing windbreaks especially suited to your farm conditions.

Issued September 1965

GPO 851 - 213 - 6

Windbreaks for the Central Great Plains

4

How to prepare land and plant trees

Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Prepare Land and Plant Trees

by RALPH A. READ[1]

Preparing the Planting Site

Preparation of planting sites is necessary for proper survival and growth of trees in the Plains. The purposes of land preparation are—

- To reduce weed and grass competition.
- To store moisture for the trees.
- To reduce wind and water erosion.
- To level the soil and reduce plant residues for planting.

Competition for moisture and light from prairie weeds and grasses can kill newly planted trees and shrub seedlings. The herbaceous vegetation of the Plains usually grows so vigorously and tall that small tree seedlings cannot survive the competition without help. Weeds and grasses use large amounts of soil moisture, leaving practically none for the trees. Weed and grass growth is so vigorous that it overtops and shades small tree seedlings.

All land preparation practices are aimed at creating more favorable growing conditions for newly planted trees and shrubs. Some practices such as irrigation, diversion ditches, and snow fences are not land preparation (soil tillage) in the usual sense. But snow fencing, for example, helps to prepare the soil for trees by trapping additional moisture.

Land Preparation Practices and What They Do

- *Contour terracing* reduces water erosion and provides extra moisture for trees planted on or near terraces.
- *Diversion ditches* provide extra moisture on planting areas by catching runoff from fields and road ditches.
- *Snow fences* trap snow for extra moisture on areas to be planted.
- *Subsoiling* breaks up or loosens the soil to a depth of 2 to 3 feet for better penetration of moisture and tree roots.
- *Summer fallow* clean cultivates soil throughout a growing season for weed control and storage of moisture and nutrients.
- *Stubble-mulch fallow* is an adaptation of summer fallow which keeps stubble on or near

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*

the soil surface for protection against wind erosion.

- *Cover crops* are close growing annual crops of grain, sudan grass, or sorghum planted the summer or fall before tree planting to trap snow and reduce wind erosion.
- *Plowing* turns under herbaceous vegetation and loosens soil for better moisture intake.
- *Disking and harrowing* controls weeds and smooths the site for the tree planting machine.
- *Spring cover crop* is a close growing grain crop planted with trees to provide protection against wind.

The first three practices—terracing, water diversion, and snow fencing—will benefit your tree planting on almost all sites. For greatest benefits, however, these should be installed at least 1 year *before* the trees are planted. Tree planting sites should always be irrigated if at all possible. The use of other practices will depend largely on the type of soil and the present crop or vegetation growing on the planting site.

Planting of cover crops may seem to contradict the statements concerning the control of vegetation to conserve moisture. The seeding of an annual crop, however, can be controlled and may be necessary to prevent extensive wind and water erosion on light, sandy soils. A cover crop planted between the tree rows will also prevent wind damage to newly planted trees.

Land Preparation Depends on Soil Types and Cover

- Very sandy soils should not be plowed, disked, or harrowed. Trees can be planted in them with a minimum of preparation. A narrow, deep furrow on which grass sod has been scalped and turned over is best. Temporary cover crops should be planted if sandy soils lack sufficient vegetation cover.
- Medium- to heavy-textured soils of cultivated land in the dry western Plains should be plowed, subsoiled, and summer fallowed to improve soil moisture. If left in rough condition through the winter, they should be harrowed in early spring several weeks before trees are planted.
- Medium- to heavy-textured soils of cultivated land in the eastern Plains can often be planted with no preparation other than light disking to reduce the stubble, if the soil contains plenty of moisture. If the soil is dry, however, land should be plowed and disked.
- Grass and alfalfa lands throughout the region, except on very sandy soils, should always be plowed and summer fallowed 1 year before tree planting.

SANDY TO VERY SANDY SOILS

Grasslands .....Scalp a 20-inch band of sod just before planting. Plant trees in narrow furrow.

Alfalfa.....Plow 1 year before; plant summer cover crop. Plant trees in cover crop stubble.

Small grain.....If good stubble, do not disturb. Plant trees in narrow furrow.

If poor stubble, plant summer cover crop. Plant trees in cover crop stubble.

Corn .....Fall disk cornstalks; plant grain cover crop. Plant trees in cover crop.

MEDIUM TO HEAVY SOILS

Grasslands .....Plow 1 year before and summer fallow. Fall seed small grain cover crop. Spring disk and plant trees.

Alfalfa.....(Same as grasslands)

Small grain.....If good moisture and stubble, fall disk. Plant trees with no further soil preparation.

If poor moisture and stubble, summer fallow. Fall seed small grain cover crop. Spring disk and plant trees.

Corn .....Fall disk corn stalks. Plant trees with no further soil preparation.

Care of Trees

When tree planting stock is received at the farm, open the bales or cartons and inspect without delay. If the trees have been properly packed and have been in transit no more than 2 or 3 days, their roots should be moist and cool. They can be considered in good condition for planting. However, if roots are dry, warm, or moldy, you should not plant the trees. Notify the office through which your tree order was made.

If trees can be planted within 2 weeks after arrival, water each day, and leave them in the carton in a cool, shady place out of the wind. If planting is to be delayed longer than 2 weeks after arrival, either place them in moist, cold storage, or heel them in in a trench.

Cold-storage temperature should be between 35 and 40 degrees F. Break open the bales or cartons, moisten the packing material, and retie loosely to maintain moisture. Check moisture condition every few days. Cold storage will keep trees dormant for several weeks until they can be planted.

If cold storage is not available, heel in the trees in a trench. In a cool, shady place dig a V-shaped trench deep enough to accommodate the full length of tree roots against the soil. Spread out the trees and roots, cover roots with soil, and water occasionally.

On the planting site keep all trees, except those being planted, in a cool, moist, shady place out of the wind. Cover roots with moist moss and burlap. During planting, carry trees in containers partly filled with water and covered with moist burlap. Tree roots should never be allowed to dry, even slightly.

When to Plant

Plant trees during the 3 to 4 weeks of early spring after the frost is out of the ground, but before the tree buds begin to swell. On the average this period ranges from April 10 to May 10 in eastern Nebraska. Planting

in western Nebraska is usually 1 to 2 weeks later. In southern Kansas planting may begin in mid-March, 2 to 3 weeks before eastern Nebraska.

Fall planting is not recommended. Trees are likely to die as a result of excessive moisture loss during winter, before they have produced new roots. Frost heaving in heavier soils can also reduce survival of fall-planted trees.

Bare-root trees should not be planted if they have already begun new top growth. Potted-root trees should normally be planted before growth starts, but can be transplanted safely for several months afterwards if watered frequently.

Plant on calm, cloudy days when possible. Stop planting when windspeed exceeds 15 miles per hour. If conditions in spring are too dry and windy for field planting, line out trees a foot apart in your garden where they can be irrigated and tended for a season. Then transplant them to the field the following spring before growth starts.

Planting Site Layout

Your local State Forester or Soil Conservation District technician will assist you in making a planting plan. The general location of tree plantings will be established when the land is prepared. For actual planting, however, you should locate the rows with flags or stakes before any trees are moved. This will prevent delays during planting.

Lay out the rows by setting stakes or flags every 150 to 200 feet, so that rows will be parallel. Crooked rows make cultivation difficult. Set stakes closer together where rows curve. Label the first stake in each row for the species to be planted, and also mark the places within rows where a different species is to be used. A row marker attached to the tractor or planter is the fastest and most accurate way of maintaining parallel rows (fig. 1). One row is laid out, and as the tractor follows it, the next row is marked on the ground.

Planting distance between trees in the rows can be estimated by pacing when you are hand planting. With machine planting, the spacing can be governed by the speed of the machine and the timing of the planters. A flagged stick of proper length can be fastened to the back end of the machine to aid in spacing.

How Deep To Plant

Trees should be planted in the field at approximately the same depth as they grew in the nursery. A common mistake is setting trees too deep. When this is done, small trees are difficult to spot during cultivation. Moreover, if cultivation is not done very carefully, the trees will be covered even more. Conifers are especially sensitive to deep planting, and may die as a result of it. Broadleaf species can tolerate deeper planting.

Planting too shallow is also a mistake, since parts of the root systems will dry out if above ground. Shallow-planted trees will also be damaged by wind whipping the tops.

F-509233

Figure 1.—If you are planting more than 500 trees, it will pay to use a machine planter. A planting crew of three men and a tractor driver can plant 5,000 to 8,000 trees per day. A row marker attached to the planting machine will assure parallel rows.

Conifers and most broadleaf species should normally be planted as they come from the nursery. Shrubs, however, can be top-pruned to force low branching. Broadleaf species and eastern red cedar having tops longer than 20 inches should also be top-pruned. Long roots, exceeding 12 to 15 inches, should be pruned.

Planting by Machine

Machine planting is a fast and reliable way to set trees (fig. 1). However, the greater speed is likely to result in less attention to the condition of the individual trees. Recognizing this, you should make a special effort to check how well the trees are being planted.

Walk each tree row behind the planter, firm the soil about each tree with your feet, and sample frequently the following items—

- proper planting depth
- roots not doubled up
- trash not mixed in with roots
- soil well-packed, leaving no air spaces
- tops not damaged
- roots not stripped
- trees firm and straight

Planting by Hand

The maximum of attention is given each tree in hand planting, and this is one way to assure success (fig. 2). Hand planting is recommended for tree windbreaks or other plantations containing 500 trees or less. Five

F-323451

Figure 2.—If you are hand planting, you can give maximum attention to each individual tree. The tree roots are placed against the vertical wall of the hole, and loose dirt is pushed against them.

hundred trees can easily be planted in 2 man-days.

Scrape all debris off the planting spot, and dig a hole deep enough to accommodate most of the tree's roots. Leave one side of the hole vertical and smooth. Hold the tree upright in one hand at proper depth against the vertical side of the hole. Shake slightly to straighten the roots and throw loose, moist soil against them. Do not throw in trash or large dry clods. Pack firmly with fist, continue to add soil, and pack again until hole is filled. Step on loose soil at the top to firm it around each tree.

The information in this leaflet will guide you in land preparation for trees and in the care and planting of tree stock. More details can be found in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. Your local Soil Conservation Service technician, county agent, or State Forester can advise you on land preparation for your particular farm and will assist you in obtaining a machine tree planter when needed.

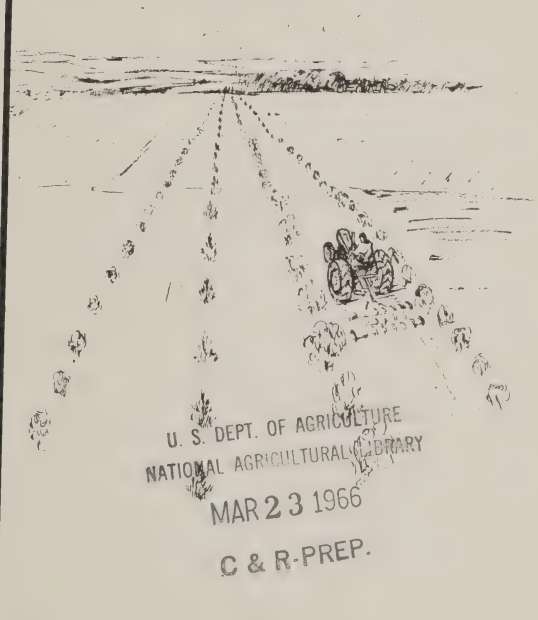
Issued September 1965

GPO 851 - 213 - 3

Windbreaks for the Central Great Plains

5

How to maintain new tree plantings



Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Maintain New Tree Plantings

by RALPH A. READ[1]

Timely cultivation and maintenance of the young trees in your windbreak (often called shelterbelt) will protect your investment and will, in the long run, insure greater success of the tree plantings. Most important, especially while the trees are young, is to keep them free of competition from weeds and grasses.

Why Control Weeds and Grasses?

The natural vegetation of the Plains, mostly grass with lesser amounts of forbs, includes many vigorous weeds. This vegetation is well adapted to the climate and soils of the region. It naturally has a great advantage over small trees in competing for moisture and nutrients—at least until the trees have had time to establish adequate root systems.

Weeds and grasses will use the available soil moisture until there is none left for the young trees. This is particularly true of large, weedy forbs and dense sods of annual and perennial grasses. Competition from prairie grasses and weeds for moisture, nutrients, and light can severely stunt or kill newly planted trees and shrubs.

Control of herbaceous vegetation is especially important in the western Plains because much less soil moisture is normally available there. Very light sandy soils are an exception—here annuals should be left after midseason to prevent soil blowing and to conserve snow. Although the need to conserve soil moisture may be less in the eastern areas during years of surplus rainfall, the control of large weeds and grasses is always necessary to prevent the overtopping and shading of young trees. Lack of sufficient light for growth can kill trees and shrubs, even when there is a surplus of moisture.

Methods of Controlling Weeds and Grasses

There are four methods for controlling weeds and grasses, all of which are aimed at reducing the amount of vegetation likely to compete with the trees for moisture,

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*

F-509856, 503717

Figure 1.—Weed control chemicals are applied in a band over the tree rows by means of a power takeoff pump on a tractor or a manually operated backpack pump.

nutrients, and light. These methods are commonly combined for most effective control:

- chemicals
- cultivation
- mowing
- mulching[2]

Chemicals

The chemicals Simazine and Karmex will do a good job of weed and grass control when applied in the proper amount at the right time. They are available from most distributors of agricultural chemicals and do not harm the trees. Sprayed in a band over the rows just after trees are planted in the spring, these chemicals will keep trees free of weeds for half the summer. Four pounds of 80 percent wettable Simazine per acre in a fine spray is recommended for medium- to heavy-textured soils; half that rate for light, sandy soils. The best weed control is obtained when rain follows spraying within a week or two.

Spraying of small areas may be done with a backpack or 2-gallon hand-operated sprayer (fig. 1). For larger areas, a power sprayer operating from a pump on a tractor power takeoff is recommended. Spray should be at a constant 30 to 50 pounds pressure, using a fairly fine nozzle such as "Teejet" No. 8002-E.[3] Solution should be continuously agitated because wettable powders tend to settle out.

[2]*Mulching with large amounts of straw or grass is not recommended because it favors high rodent populations which may damage young trees and shrubs during winter.*

[3]*Use of trade names is for information purposes and does not imply endorsement.*

Use Pesticides Safely

If you use herbicides such as Simazine and Karmex, apply them only when needed and handle them with care. Follow the directions and heed all precautions on the container label. If pesticides are handled or applied improperly, or if unused portions are disposed of improperly, they may be injurious to humans, domestic animals, desirable plants, wildlife, and fish, and may contaminate water supplies.

Cultivation

Cultivation with common farm implements is usually the surest way to control weeds and grasses in tree plantings (fig. 2). Row cultivators, spring-tooth harrows, duckfoot cultivators, sweeps, and disk harrows are all recommended and useful under various conditions. Three to five cultivations per season are normally needed for new plantings. Fewer cultivations are required as the trees reach 4 to 8 years of age.

F-351001

Figure 2.—Clean cultivation is necessary for best survival and growth of trees and shrubs in the drier areas of the Plains. This photograph shows excellent growth of cottonwoods 3 years old.

Cultivation should never ridge soil against the trees. Trees should not be cultivated as closely as corn. Small trees cannot tolerate much mechanical damage or covering up of their tops and branches. Cultivate just deeply enough to kill weeds and grasses—no deeper than 3 to 5 inches.

Cultivation between the trees in the row requires special care. Over-the-row, finger-type weeders can be used the first year or two. Special cultivators such as the mechanical rotary or grape hoe that swing in and out from a tractor are also very good for this work. If you do not have such equipment, there is no substitute for hand hoeing around each tree. This hand operation is the extra touch that gives trees the best opportunity to grow and develop.

Mowing

Mowing between tree rows combined with chemical control on the rows will provide satisfactory control of most vegetation (fig. 3). Mowing should not be regarded as a substitute for cultivation, however. When soils are extremely dry, cultivation is best. In normal to wet years, espe-

F-503716

Figure 3.—Simazine-treated tree rows will remain free of weeds through most of the growing season. Grass and weeds between the rows are mowed several times a season to keep them under control.

cially on sloping land in the eastern Plains, mowing may be better than cultivation, because it leaves a cover of vegetation between the tree rows, thus reducing water erosion.

When to Control Weeds and Grasses

The best time to control weeds and grasses is just before or during their seedling stage. Newly germinated seeds and small seedlings can be killed easily by chemicals or by cultivation.

Cultivation and chemical control should be started when the first grass and weed seeds begin to grow. Cultivation will be needed every 3 to 5 weeks thereafter, during the growing season, depending on the quantity of weed seed and the frequency of rain. Stop cultivation in August, so that some vegetation remains to protect trees during winter. Chemical control usually requires only one treatment—in the early spring—during the season.

Mowing should begin when weeds and grasses are less than 18 inches tall. This practice may be needed more often than cultivation—about every 2 to 3 weeks—since regrowth of prairie grasses is normally very rapid during rainy seasons.

Once a tree planting becomes thickly infested with weeds and grasses, especially during the middle of the growing season, it is not advisable to remove all vegetation. The sudden change in conditions may be too much for young trees, and they will often die. The only thing to do in these cases is to remove part of the overtopping weeds by high mowing.

The information in this leaflet points out the importance of proper and timely maintenance for young trees. The ultimate success of your tree planting efforts can well be determined by these practices. Whichever method or combination of methods you use, a thorough job is essential. Each individual tree has an important function in a windbreak and should be given the maximum opportunity to develop. Further information can be found in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. For local assistance in use of chemicals and for advice on cultivation and mowing, contact your Soil Conservation Service technician, county agent, or State forester.

Issued September 1965

GPO 851 - 213 - 4

Windbreaks for the Central Great Plains

6 How to protect them from damage

Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Protect Them From Damage

by RALPH A. READ[1]

Timely protection of young trees and established windbreaks (often called shelterbelts) will guard your investment and, in the long run, insure greater success of the tree plantings. Protection is most important while trees are young, but well-established trees also require frequent inspection to detect damage by animals, insects, and diseases.

Why Protection Is Needed

Trees growing in the Plains must endure the ever-present extremes of drought, heat, cold, and the hazards of wind and hail. Little can be done to control these conditions; thus, considerable damage may occur when they reach extremes. Weather-caused damage often prepares the way for other types of injury. Trees weakened by prolonged drought or damaged by wind and hail are much more susceptible to the attacks of insects and disease-causing organisms.

On the other hand, some damaging agents can be avoided or controlled. Positive protection for your tree investment is possible against damage from

- livestock
- rodents
- insects
- diseases
- fire

Damage by Livestock

It has been said, "a good windbreak makes a poor pasture—if pastured it soon becomes a poor windbreak." Windbreaks or any tree plantations used as shade and feed lots by livestock will be damaged (fig. 1). Cattle, horses, and goats browse foliage from the lower limbs of trees and frequently break down small trees. All of them will browse young seedlings, compact the surface soil, and expose tree roots by trampling.

When lower foliage of windbreaks is destroyed, the wind will sweep through under the trees, and may start soil blowing. Leaf litter, important for holding moisture and maintaining surface soil permeability, will be blown away. The windbreak's ability to slow wind and stop snow will be greatly reduced.

Compaction of the soil reduces its

[1]*Silviculturist, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*

F-485794

Figure 1.—Use of windbreaks as livestock shade and feed lots results in deterioration of tree plantings. Browsing and trampling compacts the soil, kills the trees, and opens the windbreak so it is no longer effective in slowing wind.

permeability so that water runs off instead of soaking into the soil. All trees will gradually deteriorate as the surface soil becomes more compact. When livestock is allowed continued use of shelterbelts, all small trees and shrubs will soon be killed. Larger trees will lose health and vigor, and growth will be reduced.

The only remedy for this type of damage is to prohibit livestock use of tree plantations. Build and maintain a stock-tight fence, and keep all animals outside it.

Damage by Rodents

Damage by rabbits, mice, ground squirrels, gophers, and other rodents is usually severe on young trees (fig. 2). Sometimes a new planting is so badly damaged that extensive replanting is necessary.

F-365490

Figure 2.—Rodents usually cause greatest damage to smaller trees and shrubs. When the bark is eaten from the main stem, the tree is girdled and dies.

Rabbits often girdle or debark tree stems and limbs, killing them back to the ground. The tops of young pines or spruces are sometimes chewed off. During some winters, mice will girdle trees beneath the snow. Gophers may chew the roots of newly planted trees.

If you know the population of rodents is high near your tree planting area, you should begin a control program the winter before planting. Use a poison containing strychnine or arsenic. Strychnine alkaloid mixed with a starchy paste or alfalfa meal and daubed on the small trees is very effective. These chemicals are most effective when applied directly to parts of the trees likely to be damaged. **Warning: Strychnine and arsenic are deadly poisons. If bait boxes or pellets are used, be careful to place them where domestic animals cannot reach them. Collect and bury the dead rodents.**

Trees can also be protected from girdling by rodents by wrapping the stems with aluminum foil. Other methods such as shooting or trapping the rodents or treating trees with a repellent are less effective, but will help reduce the damage if rodent populations are not too high. For detailed information on the use of poison baits, contact your county agent or State Forester.

Damage by Insects

Insect populations can build up to damaging proportions before you are aware of the problem. Frequent inspections and alertness in recognizing insect damage in the early stages are the main ingredients of an effective program.

Whenever you suspect insect damage, collect some specimens of the insect and damage for identification. Take or mail the specimens to the county agent or Extension Service entomologist. He will identify the insect, determine the need for control, and advise you of control measures.

Insects damaging to trees and shrubs are grouped into categories depending on the plant parts they usually affect and their feeding habits:

(1) Leaves eaten, mined, or galled.
(2) Buds, shoots, twigs, or flowers damaged.
(3) Main stem and large branches girdled, weeviled, or bored.
(4) Sap sucked from leaves, twigs, branches, bark.

The leaf eaters are the most common insects attacking trees in the Plains. Many of them are general feeders, likely to occur on any tree and shrub species. For example, the spring and fall cankerworms, hornworms, tent caterpillars, webworms, bagworms, leaf beetles, and grasshoppers may attack and damage many kinds of trees and shrubs during epidemic conditions (fig. 3). Normally, most trees and shrubs can withstand a single defoliation; they will soon recover if weather conditions are favorable.

Damage to buds, shoots, and twigs is usually more serious than defoliation because recovery is slower. For example, the pine tip moth, a terminal shoot borer, kills new shoots and

stunts the height growth of ponderosa pines.

Insects attacking the main stem or large branches of trees are even more damaging. Cottonwood borers, roundheaded and flatheaded borers, and carpenter worms frequently kill outright some broadleaf species. The smaller European elm bark beetle carries the Dutch elm disease from dead or dying elms. Pines and redcedars are not often attacked by borers or bark beetles except during extremely dry periods. Other serious pests which girdle the main stems of smaller trees include the cutworms and armyworms.

Sap feeding insects such as scales, mealybugs, aphids, and red spider mites are nearly always present in the Plains area. They feed on most trees and shrubs used in windbreaks. Normally the damage they cause is not serious, but occasionally they get out of control owing to favorable weather conditions and lack of predators. Their effects are usually seen for 1 or 2 years, after which natural enemies bring about control.

Damage by Diseases

Trees infected by disease-causing organisms are more likely to be killed when weakened by extreme drought than if maintained in vigorous conditions by cultivation and irrigation. However, disease-causing organisms can attack and kill perfectly healthy trees. Frequent inspections and alertness in recognizing disease damage

F-366778

Figure 3.—Foliage insects may in some seasons completely defoliate windbreak trees and shrubs, as grasshoppers did to part of this row of caragana.

in the early stages are necessary for effective protection.

Whenever you suspect disease damage, request the aid of the county agent or Extension Service plant pathologist. He will identify the disease, determine the need for control, and advise you of control measures.

Diseases are generally of three types, those affecting (1) foliage, (2) stems and branches, or (3) roots.

Most tree and shrub species used in windbreaks are susceptible to foliage diseases that are caused by fungi, bacteria, viruses, or some noninfectious agency. These organisms reduce the area capable of photosynthesis by penetrating and ultimately killing the leaf tissues. They can also enter the leaf stems and move into the water conducting system. Foliage diseases are usually damaging only when they cause extreme defoliation. Some, however, invade twigs where the causal agencies persist and cause repeated foliar infection.

Leaf rust fungi, which often require an alternate host to complete their life cycles, are fairly common on the tree species of the Plains region. Cottonwood leaf rust, green ash rust, and cedar-apple rust are examples.

Needle cast diseases frequently are epidemic on ponderosa, Austrian, Scots, and other pines during warm, humid weather. The trees can become seriously weakened after several consecutive years of heavy infection by these diseases.

Stem and branch diseases are generally more severe than foliage diseases in their effect on tree growth. They frequently affect the water conducting system, checking the movement of water from roots to leaves. When this happens the entire tree, or large portions of it, wilts and dies. Dutch elm disease, phloem necrosis, and *Dothiorella* wilt are examples of stem and branch diseases on elms. *Diplodia* on Russian-olive causes wilting and death of stems and branches. Needle and twig blights are common on the Austrian pines.

Wood-rotting fungi frequently enter trees through wounds on the main stem and branches. Although these fungi rarely cause death even after several years, they weaken trees and favor breakage during wind- and snow-storms.

Bacterial infection on elms causes wet-wood (known also as slimeflux), which brings about gradual deterioration and sometimes death of stems and branches. *Cytospora* canker, assumed to attack only weakened trees, may kill cottonwoods and willows.

Root diseases, including those caused by nematodes, are often more difficult to diagnose than diseases of aboveground tree parts. Root disease fungi such as *Fomes annosus* and *Phytophthora* species may occur in windbreak trees; however, little is known of the present distribution of these disease agencies. The cotton root rot fungus *Phymatotrichum omnivorum* is present in some areas of Oklahoma and Texas. This fungus will kill many species of trees planted on those areas, although a few are somewhat resistant to it.

Damage by Fire

Windbreaks damaged by fire will seldom recover to grow again into useful barriers. All conifers will be killed outright by even a rather light ground fire. The larger and taller broadleaf trees may not be killed if the fire was light and stayed on the ground. Many shrubs will sprout and recover to some extent.

However, fires in windbreaks are seldom light or slow. Usually there is an abundance of herbaceous vegetation which, when dry, will carry fire high into the tree crowns.

The best way to protect your windbreaks from fire is to maintain a cultivated strip on all sides of the trees. This is especially needed when windbreaks are close to roads. Windbreaks, of course, are not recommended within 300 feet of highway rights-of-way.

The information in this leaflet points out the importance of protecting your tree windbreaks from damages that can be controlled. Additional information on protection measures for Plains trees and shrubs can be found in Agricultural Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 50 cents. For local help in tree protection, contact your Soil Conservation Service technician, county agent, or State forester. Your local technicians can put you in touch with tree insect and disease specialists.

Issued September 1965

GPO 851 - 213 - 1

Windbreaks for the Central Great Plains

7 How to manage established plantings

Rocky Mountain Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture

Windbreaks for the Central Great Plains

How to Manage Established Plantings

by Ralph A. Read[1] and David F. Van Haverbeke[1]

Windbreaks (often called shelterbelts) need to be managed to keep them healthy and effective. As a forest can be tended to yield more wood, so can a tree windbreak be managed to maintain it as an effective windbarrier. Good management of windbreaks has two purposes:

- to maintain and improve vigor and growth of individual trees and shrubs.
- to maintain and improve windbreak structure for maximum effectiveness.

Management should begin after trees are well established but before crowding starts. No definite number of years after planting can be recommended because this depends on the tree species, the rate of growth, and the spacing. Under average conditions, however, management will probably need to be started between the 5th and 10th years after planting. By this time the faster growing broadleaf trees will be 20 to 30 feet tall, and may be crowding the conifers in adjacent rows. Slow-growing trees and shrubs will begin to show effects of overtopping.

[1]*Silviculturists, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture field headquarters at Lincoln, Nebr., maintained in cooperation with the University of Nebraska.*

How to Evaluate Management Needs

Windbreak trees are planted close together to provide a barrier against the wind as soon as possible. However, as the trees and shrubs grow larger they will begin to crowd one another. This crowding must be relieved to keep the trees vigorous and with sufficient foliage to form an effective windbarrier. Thus, one of the aims of management is to prevent loss of tree vigor *before* crowding becomes severe.

Look for signs of deterioration that appear in shelterbelts suffering from shading, crowding, moisture stress, etc. Some of these are premature foliage loss, poor color foliage, reduced live crown, increasing incidence of diseases and insects, and reduced annual growth.

Estimate the height, width, and density of each individual windbarrier, and rate each species or row for its contribution to windbreak effectiveness (fig. 1). If vigor is declining, determine which rows or individual trees can be removed to relieve the crowding. If insects and

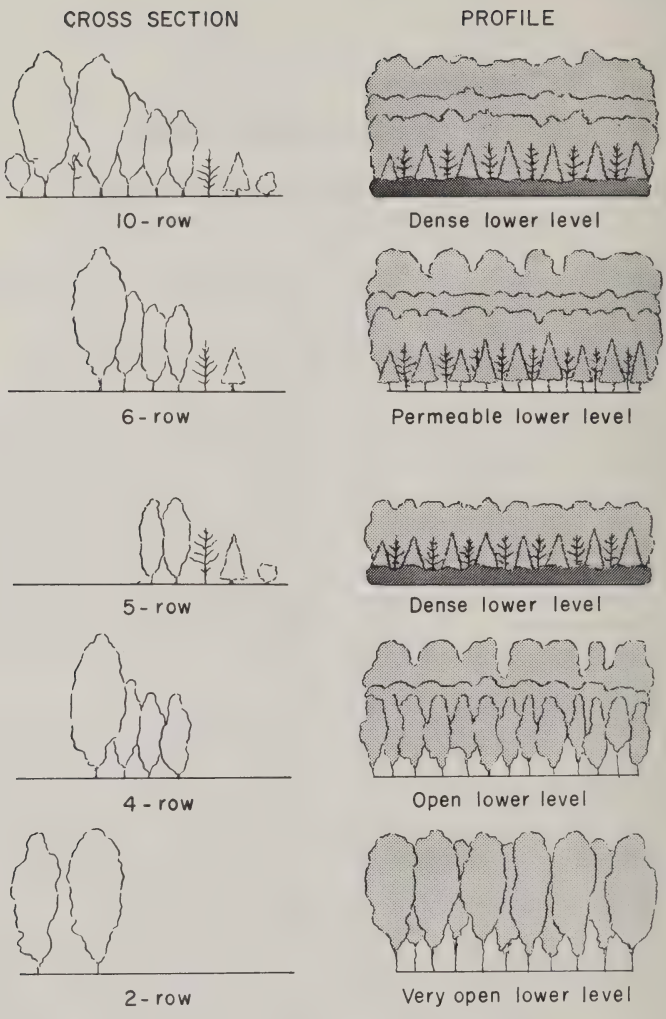


Figure 1.—When 10-row windbreaks are to be reduced in width, the resulting windbreak profile should be considered. These sketches give some idea of how structure is modified when tree rows are removed.

diseases are threatening, determine what controls are necessary. Some of the most common management needs are described below.

Some Specific Management Needs

• *Relieve crowding.*—In many 20-year-old shelterbelts the interior tree rows, especially hackberry, honeylocust, and Siberian elm, show extreme effects of crowding. The signs are short or narrow crowns of low vigor and the presence of diseases and much dead wood. Thinning of these interior rows of trees will increase vigor and growth of the remaining trees. The increase of foliage brought about by such treatment will also improve the density, thus the effectiveness, of the shelterbelt.

• *Release conifers.* — Overtopping and crowding of pine and red cedar rows by fast-growing broadleaf species, such as Russian-olive, green ash, and boxelder, is a common problem in many 25-year-old shelterbelts of the old "Shelterbelt project." Since conifers are a most important component of shelterbelts for longevity and for effectiveness through the year, they should receive special care and treatment. Pines and cedars should be released by cutting the adjacent rows of overtopping broadleaf species (fig. 2).

• *Add conifers.*—Many windbreaks contain no conifers, or only a few scattered pines or cedars. Such windbreaks do not provide needed density and continuity of foliage during the winter and early spring. While most leafless broadleaf trees and shrubs will provide adequate barriers for snow control, they are poor protection against wind and the ensuing hazard to crops. A major objective of management should be to add red cedars and pines to all shelterbelts lacking conifers.

• *Modifying low-level density.*—As trees and shrubs grow they tend to lose their lower branches, especially when crowded. Since shrubs are supposed to form a dense barrier close to the ground, it is important that they not be allowed to grow tall and spindly. If they are cut back to the ground every 4 or 5 years, they will sprout anew and provide dense foliage.

F-503719

Figure 2.—Red cedars can be released from overtopping and crowding by cutting an adjacent row of green ash. Stump sprouts of the ash help to increase lower level foliage density of the shelterbelt.

Many shelterbelts having conifers on the south side are too open on the north side. Snow can blow through the barrier and drift leeward of the conifers across road rights-of-way. Such shelterbelts need new rows of red cedar planted on the north side to control the snow.

• *Reduce width of windbreak.*—Frequently, windbreaks containing 10 or more rows of trees and shrubs may be reduced in width by removing rows that contribute little to density and effectiveness of the barrier (fig. 3). This is good practice if done without changing the windbreak structure appreciably.

F-503720

Figure 3.—Crowding between rows of Siberian elm can be relieved by cutting alternate rows. This space allows the tree crowns to enlarge and will result in increased vigor.

In windbreaks containing effective rows of conifers, the side opposite from the conifers can often be sacrificed to reduce width. However, all rows of Siberian elm which alone provide the height needed for an effective barrier should not be cut out. Examples of the windbreak profiles after rows are cut to reduce width are shown in figure 1.

Methods of Management

Thinning and release.—If your windbreaks show signs of deterioration and loss of vigor, remove some of the trees to relieve this condition. A few trees around individual trees to be favored with more space can be removed. Or an entire row of trees that is crowding a more desirable row of trees can be removed.

To relieve crowded shelterbelts having two or more rows of Siberian elm at close spacing, cut one or alternate rows of the elm. Or cut alternate trees within each row, so that the crowns of remaining trees can expand to improve the profile density.

To release conifers, cut the overtopping trees if conifer survival has been good despite the crowding. If only a few conifers remain, however, do not bother to release them. When pines are released, the stumps of the cut broadleaf trees should be allowed to sprout to provide a renewal of low-level density. These sprouts should then be cut back every 4 or 5 years to prevent more crowding. In releasing red cedar from overtopping trees, however, the stumps of cut trees can be treated with a chemical to prevent sprouting because red cedar crowns

will thicken and provide low-level density.

Before starting a thinning treatment, consider its effect on the windbreak structure. Removing sufficient trees to end all crowding may result in too porous a windbreak. This is especially true in plantings that have grown for 20 years or more with no previous management. In a crowded shelterbelt the inner tree rows will not have any lower foliage, and when outside tree rows are removed an extremely open windbreak will result.

Management practices should be put into effect a step at a time, instead of all at once. In this way the windbarrier can continue to function effectively during the silvicultural work. For instance, if you cut the outside shrub rows in the spring and allow them to sprout, you can thin trees within the windbreak a year later, without losing much lower level density. Or you could plant new shrub or tree rows on either or both sides of the shelterbelt a year or two before beginning the cutting treatments.

Coppicing. — Cutting trees and shrubs and managing the resulting coppice sprouts is an effective way to control growth of large shrubs which overtop conifers, and at the same time improve low-level density of windbreaks.

Most broadleaf tree and shrub species used in Plains shelterbelts will sprout when their woody stems are cut back to the ground. The regrowth foliage is usually much thicker at ground level than the plant had previously, because many more stems are produced. American plum, lilac, chokecherry, honeysuckle, caragana, and tamarisk may all be improved by this practice.

Trees originally planted to function as shrubs, such as Russian-olive, boxelder, Russian mulberry, and osage-orange, may also be improved by cutting back to the ground. With these tree species, however, the cutting must be repeated every 4 to 5 years to maintain low foliage.

Interplanting. — To improve broadleaf shelterbelts for maximum wind reduction, plant several rows of conifers to strengthen the barrier density. Eastern red cedar can be planted almost anywhere within or on either side of well-established shelterbelts, because this species can tolerate less light and more crowding than other conifers. Pines should usually be planted on the south side of established trees. However, if pines are desired on the north side of the shelterbelts, allow at least 20 feet space between them and existing broadleaf species.

In many instances, conifers can be planted simply as additional rows north of the existing trees. In other cases, however, it is better to remove several rows of broadleaf species on the north before planting them. All newly established tree rows should be maintained by one of the recommended cultivation methods for several years.

Use of natural reproduction. — In most well-established windbreaks that have been protected from livestock use and fire, there is an abundance of natural seedlings. Elms, ash, hackberry, lilac, chokecherry, plum, box-

elder, mulberry, honeylocust, black locust, and eastern red cedar seedlings are usually present. These seedlings are especially abundant in openings created by deteriorating, short-lived trees. This natural seedling growth in the understory will help you maintain lower level foliage. This understory will also catch and hold more snow to replenish soil moisture within the shelterbelt.

If windbreaks are vigorous and fast-growing, the understory reproduction need not be treated at all. On the other hand, if the barrier is beginning to deteriorate, understory growth should be stimulated to replace the older trees. One way to manage the seedling reproduction is to cut or plow out all saplings except those in a narrow band where a new row is desired. Another way is to select the best trees for release at 6- to 10-foot spacing, and cut all the remaining understory.

Either of these alternatives or modifications of them will likely be necessary to develop windbreaks from natural reproduction. Lacking treatment, the natural reproduction is likely to grow slowly, lose its lower foliage, and develop into spindly, sparse-crowned trees of little value for windbreaks.

Pruning. — Many owners prune the lower branches of trees, especially conifers, with the idea of improving their appearance. While this may improve the appearance of individual trees, it reduces the effectiveness of the windbreak plantings.

Since the primary purpose of a windbreak is to control wind movement by foliage density, removing lower limbs is not generally recommended. Pruning should be used only for a specific purpose — for example, as a sanitary measure to reduce incidence of diseases, and then only on the advice of a tree disease specialist. Pruning can be used to create an open lower level to prevent snow drifting within and leeward of barriers, but this also should be done only in special cases on advice of a windbreak technician.

In pruning, the branches should be cut close to the trunk with a saw. The best time for pruning is in spring just before growth starts. This will favor rapid callusing and growth over the wound. Large wounds (more than 2 inches diameter) should be protected by covering with asphalt paint.

Additional information on the management of windbreaks or shelterbelts can be found in Agriculture Handbook 250, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 for 50 cents. For local assistance, contact your Soil Conservation Service technician, district forester, or State forester.

Issued September 1965

GPO 851-213-5